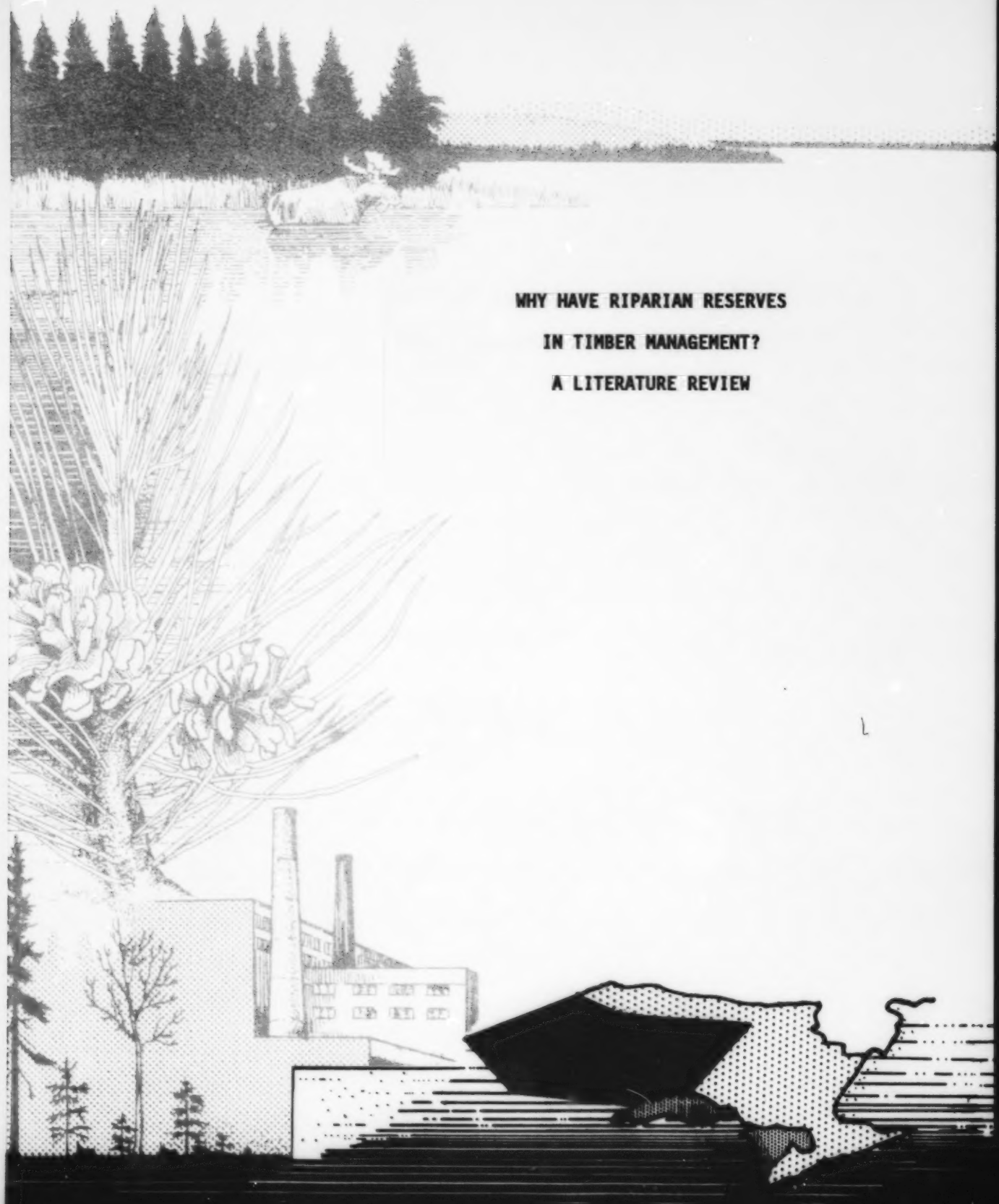

WHY HAVE RIPARIAN RESERVES IN TIMBER MANAGEMENT? A LITERATURE REVIEW

NORTHWESTERN ONTARIO FOREST TECHNOLOGY DEVELOPMENT UNIT

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by

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ABSTRACT

Riparian reserves are an important timber management practice designed to protect wildlife, fisheries, tourism, and water quality values. This report briefly presents the rationale for riparian reserves as a management tool and reviews literature pertinent to forest management in northwestern Ontario.

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INTRODUCTION

A riparian habitat is located between aquatic and upland areas (Thomas et al 1979). Amphibian, terrestrial, and aquatic species are often confined to riparian zones or the adjacent aquatic zones, although some terrestrial species only utilize these zones for food, water, or shelter (Davis 1977). The activities of recreationists also tend to be concentrated in the riparian and adjacent aquatic zone (Thomas et al 1979).

Timber management operations cause changes to the riparian habitat which may affect fish, wildlife, and tourism values; therefore, no-cut or selective harvest reserves to protect these values during timber management are required in Ontario (Ontario 1987, Ontario 1988a, Ontario 1988b) under the Class Environmental assessment for Timber Management. This literature review summarizes the value of riparian reserves and their usefulness in mitigating the effects of timber management on fish, wildlife, and tourism values.

FISH

Riparian reserves help prevent physical, chemical, and biological changes that can occur to lakes, streams, and wetlands during and after timber management operations. The removal of riparian vegetation may lead to the degradation of stream water quality (Gordon and Kaushik 1986) by changing water yield, erosion, sedimentation, turbidity, water temperature, nutrient content, organic debris or by possibly decreasing light penetration and oxygen content.

Deforestation of a watershed results in increased water yield because the water that would have been intercepted or transpired by plants is free to escape through the soil or as surface runoff (Chapman 1962). Water yield increases in proportion to the amount of riparian vegetation removed (Chapman 1962; Brown and Beschta 1985; Corbett and Lynch 1985). This is especially true in boreal forests

where conifers use more water than deciduous trees (Brown and Beschta 1985). Soil compaction caused by roads and skid trails also reduces soil permeability which can further increase surface runoff (Everest et al 1987).

An increase in water yield alters the seasonal distribution of stream flows. Increased peak flows in the spring can cause scouring of bottom sediments resulting in dislodgement of fish eggs, larvae, and benthic invertebrates (Chapman 1962). High flows also create wider streams and can cause a loss of pools for fish (Beschta and Platts 1986). The effects of high water yield continue until revegetation of the watershed takes place (Gordon and Kaushik 1986).

Riparian vegetation protects shorelands against the scouring effects of rain and surface runoff, and protects the shoreline from stream or wave action. Removal or disturbance of this vegetation by timber management activities such as road construction, harvesting, and mechanical site preparation increases the risk of soil erosion and eventual sedimentation of water bodies (Beschta and Platts 1986, Everest et at 1987). Roads and log landings contribute to erosion of materials into streams because they are compacted and lack vegetation (Van Groenwoud 1977, Corbett et al 1978). As the slope of the terrain increases, so does the risk of erosion (Van Groenwoud 1977). Felled timber in a stream can also have a damming effect resulting in bank cutting and subsequent erosion.

Soil erosion may lead to the introduction of sediments and suspended soil particles (sand, silt and clay) into the stream. Suspended silt and clay increase turbidity and have several harmful effects on fish and fish habitats. Photosynthetic activity of aquatic plants such as macrophytes and algae or phytoplankton is limited due to reduced light penetration resulting in a reduction or change in distribution of aquatic vegetation. Levels of dissolved

oxygen can also be reduced due to light reduction and the decomposition of suspended organic matter (Chapman 1962). Suspended sediments can cause damage to gill membranes of fish, and reduce survival of fish that feed by sight (Corbett et al 1978).

Deposited, or bedload sediments are more harmful to fish and their habitats than suspended particles. Finer sediments can cause damage to spawning beds and reduce reproduction in fish (Corbett et al 1978, Beschta and Platts 1986, Everest et. al. 1987). Everest et. al. (1987) reported that sediments in the spawning beds interfere with the intra-gravel flow of dissolved oxygen and caused suffocation of eggs and alevins. The sediments may also act as a physical barrier to the emergence of young fry. The diversity and abundance of benthic fish food organisms is also depleted by the accumulation of fine sediments in the stream (Corbett et al 1978).

Since riparian vegetation shades streams, partial or complete removal will expose stream water to increased amounts of sunlight resulting in increases in water temperature and photosynthetic activity (Chapman 1962, Brown and Krygier 1970, Brazier and Brown 1973, Burton and Likens 1973, Corbett et al 1978, Brusnyk and Gilbert 1983, Corbett and Lynch 1985, Galladay and Webster 1988). Brown and Krygier (1970) observed that the average temperature of water in a small stream increased by an average of 6 degrees Celsius following the removal of shading riparian vegetation. They concluded that smaller streams and tributaries would be more susceptible to large changes in temperature than big streams, and that vegetation cover of these streams, particularly cold water streams, is very important. These streams will exhibit higher temperatures for about six years or until shading is reestablished. Studies in northwestern

Ontario indicated that small streams had an average temperature increase of 5 degrees Celsius (Nicolson 1975).

Riparian reserves are not always solid, no-cut reserves along a shoreline. Strip or block cut reserves are sometimes used in order to maximize the amount of timber extracted from an area, while maintaining the beneficial effects of the reserve. This type of operation may produce temperature zones in the stream that represent different thermal habitats (Burton and Likens 1973) and cause changes in stream composition. In areas where alternate strip cuts occurred along a stream, there was a four to five degree Celsius increase in water temperature adjacent to the strip cuts. This resulted in both the extirpation of large populations of two-lined salamanders and the presence of blooms of algae (Burton and Likens 1973). In this incident a solid riparian reserve may have protected the salamander population and prevented the algal blooms.

Shading of a stream by riparian vegetation has a strong influence on trout carrying capacity (Wesche et al 1978). Not only are shaded resting areas provided, but more important, the roots of the riparian vegetation are critical to the development of undercut banks which are necessary to maintain high trout populations.

Forest removal results in the addition of nutrients into the stream environment (Chapman 1962; Corbett, et al 1978; Brown and Beschta 1985). Nutrients which are no longer consumed by trees are leached through the soil, into the stream. Phosphorus is the most limiting factor to the productivity of aquatic plants in Ontario waters (Allin and Ward 1988). The occurrence and cycling of phosphorus in the forest after timber harvest has been well documented, and studies in northern Ontario indicate increased phosphorus input into streams after timber harvest (Nicolson 1982). This may result in an

increase in both the production of aquatic plants and in fish growth rates. However, subsequent decomposition of this biological material may decrease the level of dissolved oxygen (Corbett et al 1978).

Concentration of nutrients is highest in areas where revegetation is slow (Corbett et al 1978). The use of chemical herbicides to prevent regrowth of vegetation can lead to continued leaching of nutrients into the stream (Platts et. al. 1987).

In streams, some quantities of organic debris produced during harvesting operations may provide a food source for organisms with food habits flexible enough to use it (Golladay and Webster 1988). It can also provide shade and protection within the aquatic environment. However, excessive debris in a stream may reduce flow rates, cause a reduction in concentration of dissolved oxygen (Ontario 1988a), and logging debris may also prevent fish from reaching spawning areas (Chapman 1962). Riparian reserves reduce the input of logging debris and its negative effects.

FISH HABITAT PROTECTION

There are four major fish habitat types in Ontario. They are: (1) lake trout lakes, self sustaining brook trout lakes and aurora trout lakes; (2) other lakes; (3) coldwater streams; (4) coolwater and warmwater streams (Ontario 1988a). The presence of a riparian reserve will protect these habitats by shading the waterbody and reducing runoff, erosion, sedimentation, and leaching of nutrients into the stream (Brown and Krygier 1970, Brazier and Brown 1973, Burton and Likens 1973, Dykstra and Froehlich 1976, Corbett et al 1978, Corbett and Lynch 1985, Everest et al 1987). Keeping roads, skid trails, and landings

away from lakes and streams will also help protect fish habitats (Everest et al 1987).

"The Timber Management Guidelines for the Protection of Fish Habitat" (Ontario 1988a) address the concerns of timber operations near waterbodies, and suggest management operations that protect fish habitat and water quality.

WILDLIFE

Riparian zones offer food, water, and shelter values to many wildlife species, and often act as a travel corridor between habitats for some animals (Thomas et al 1979, Cross 1985). The size and shape of the riparian reserve, and its proximity to other habitats will determine the extent of use by wildlife (Diamond 1975, Budd et al 1987).

Moose in Ontario have a strong annual requirement for sodium, much of which is obtained by feeding on aquatic vegetation (Timmermann and McNicol 1988). "The Timber Management Guidelines for the Provision of Moose Habitat" (Ontario 1988) suggest leaving reserves around streams and ponds to provide sheltered access to aquatic feeding areas. Buckland and O'Brien (1988) observed that riparian reserves left adjacent to moose aquatic feeding areas were usually used for that purpose. However, in areas where trees were harvested down to the shoreline, moose continued to feed on aquatics during the summer (Brusnyk and Gilbert 1983). The increase in light, and the subsequent increase in photosynthetic activity resulting from the removal of shoreline vegetation, caused an abundance of aquatic vegetation (Brusnyk and Gilbert 1983), but a reduction in plant species that moose prefer.

Riparian reserves can greatly contribute to the overall habitat requirements for moose, especially for winter habitat (Brusnyk and Gilbert 1983).

Other wildlife species such as small mammals, birds, and amphibians are affected by the removal of shoreline vegetation. Riparian reserves reduce the loss of small mammals that can occur if all riparian vegetation is removed (Cross 1985). Carothers et al (1974) noted a 46 percent reduction in a population of breeding birds on a thinned riparian zone. Removal of the entire riparian vegetative component could have resulted in the elimination of some bird species from the area.

TOURISM

Recreational activity is usually concentrated in and around shoreline areas. Riparian reserves retain the original aesthetic values of the area surrounding a lake or stream while maintaining other important experiential values such as the feeling of remoteness (Thomas et al 1979). Water qualities such as taste, colour, and odour are also preserved (Corbett and Lynch 1985). Riparian reserves are used to protect canoe routes, portages, shoreline lunch sites, channels connecting lakes, and out-post camps, while also being used to regulate public access. The "Timber Management Guidelines for the Protection of Tourism Values" suggest methods of designing reserves and cutovers that provide maximum preservation and protection of these values, while at the same time maximizing amount of timber cut.

RESERVE SPECIFICATIONS

The size and shape of a riparian reserve influences its effectiveness in protecting fish, wildlife, and tourism values, and on the amount of inconvenience to timber operations. Reserve width should be related to canopy height and density,and if dealing with a stream, the stream width and stream discharge

(Brazier and Brown 1973). Reserve widths that have proved effective in preventing temperature fluctuations of stream water by shading stream or lake shoreline range from five to 27 metres (Brazier and Brown 1973, Burton and Likens 1973, Dykstra and Froehlich 1976, Corbett et al 1978, Corbett and Lynch 1935). In order to protect the entire stream environment, it was recommended that reserves range from 30 to 120 metres or even larger, depending on circumstances such as slope and soil conditions (Corbett and Lynch 1985).

The condition of the riparian reserve is also very important in protecting the stream or lake environment. Overmature timber is not as effective in utilizing available nutrients (Corbett and Lynch 1985), and overmature or unhealthy timber often have difficulty withstanding the wind action which results from clearcuts; consequently, blowdown may occur (Buckland and O'Brien 1988).

The orientation and shape of reserves can alter their life span. Large amounts of blowdown can result when long narrow strips of timber are exposed to prevailing winds (Buckland and O'Brien 1988). Orientation of reserves parallel to prevailing winds may be more important than strip width, even though wider reserve strips often have less blowdown (Buckland and O'Brien, 1988, Stephenson 1988). The possible results of blowdown are increased runoff, erosion, sedimentation, nutrient leaching, and deposition of debris into the stream. Exposure of the stream to more sunlight will also occur. High amounts of blowdown timber make travel within the riparian reserve difficult for some wildlife while increasing hunting and refuge opportunities for others because of the increase in structural diversity. Finally, maintenance of the reserve is important for the preservation of aesthetics.

CONCLUSIONS

Riparian reserves are essential for the protection of stream ecosystems. The timber management guidelines for the protection of fish habitat, moose habitat, and tourism values (Ontario 1987, Ontario 1988a, Ontario 1988b) are beneficial tools for helping forest managers decide the size and shape of a reserve. More information on the effectiveness of riparian reserves in northern Ontario is necessary in order to determine if the guidelines are being followed and are working. There is also a need for more information on the use of riparian reserves by other wildlife species such as predators, small mammals, cavity nesting ducks, and other riparian birds. The ESSA guidelines for resource protection (McNamee et al 1988) describe the framework for a monitoring program to obtain this information.

LITERATURE CITED AND ABSTRACTS

Allin J. and N. Ward 1988. Potential effects on the aquatic environment, their prevention, mitigation and enhancement (including herbicide use). p.774-804. In:OMNR Statement of Evidence, Panel X1: Renewal. Submitted to Environmental Assessment Board (No.NR-AA-03).

Allin J. and N. Ward. 1988. Harvest: Potential effects on the aquatic environment, their prevention, mitigation and remedy. pp. 832-877. In: OMNR Statement of Evidence, Panel X: Harvest. Submitted to Environmental Assessment Board (No. NR-AA-03).

Beschta, R.L. and W.S. Platts. 1986. Morphological features of small streams: Significance and Function. Water Resources Bulletin 22(3):369-379.

Throughout the United States, land managers are becoming increasingly aware of the importance of small streams for a wide range of resource benefits. Where channel morphology is modified or structural features are added, stream dynamics and energy dissipation need to be considered. Unit stream power, defined here as the time-rate loss of potential energy per unit mass of water, can be reduced by adding stream obstructions, increasing channel sinuosity, or increasing flow resistance with large roughness elements such as woody root systems, logs, boulders, or bedrock. Notable morphological features of small streams are pools, riffles, bed material, and channel banks. Pools, which vary in size, shape and causative factors, are important rearing habitat for fish. Riffles represent storage locations for bed material and are generally utilized for spawning. The particle sizes and distributions of bed material influence channel characteristics, bedload transport, food supplies for fish, spawning conditions, cover, and rearing habitat. Riparian vegetation helps stabilize channel banks and contributes in various ways to fish productivity. Understanding each stream feature individually and in relation to all others is essential for proper stream management. Although engineered structures for modifying habitat may alter stream characteristics, channel morphology must ultimately be matched to the hydraulic, geologic, and (especially) vegetation constraints of a particular location. (KEY TERMS: streams; habitat; pools; riffles; bed material; streambanks)

Authors' abstract.

Brazier, J.R. and G.W. Brown. 1973. Buffer strips for stream temperature control.
Res. pap. 15 from Res. Lab., School of Forestry, Oregon State University, Corrvallis, Oregon. 9p.

During clearcut logging, complete removal of the canopy and the shade it provides to small streams can cause large increases in water temperature. Such increases in temperature can be prevented if buffer strips of vegetation are left along the stream to provide shade. The purposes of

this paper are to define the characteristics of buffer strips that are important in regulating the temperature of small streams and to describe a method of designing buffer strips that will insure no change in stream temperature as a result of logging and at the same time minimize the amount of commercial timber left in the strip.
Commercial timber volume alone is not an important criterion for temperature control. Further, the width of the buffer ship is also not an important criterion. For the small streams studied as part of this research, the maximum shading ability of the average buffer strips forereached within a width of 80 feet. Specifying standard 100 to 200 foot buffer strips for all streams generally will include more timber than necessary. The canopy density along the path of incoming solar radiation best describes the ability of the buffer strip to control stream temperature. An estimate of this value can be obtained easily by foresters laying out buffer strips in the field and will insure proper design of the buffer strip for control of stream temperature.

Authors' abstract.

Brown, G.W. and J.T. Krygier. 1970 Effects of clearcutting on stream temperature. Water Resources Res. 6:1133-1139.

The principal source of energy for warming streams is the sun. The amount of sunlight reaching the stream may be increased after clear-cut logging. Average monthly maximum temperatures increased by 14°F and annual maximum temperatures increased from 57° to 85°F one year after clear-cut logging on a small watershed on Oregon's coast range. In a nearby watershed where strips of brush and trees separated logging units from the stream, no changes in temperature were observed that could be attributed to clear-cutting.

This report describes the potential effects of renewal on the aquatic environment as well as measures which can be taken to prevent or mitigate potential negative effects. Measures to enhance potential positive effects are also discussed.

Little information is available about the effects of renewal specific to the aquatic environment in Ontario. Consequently, much of the information given in this report concerning potential effects was obtained from studies carried out elsewhere, but having some relevance to Ontario conditions.

The report includes a number of photographs used to assist in understanding potential effects and their mitigation.

Authors' abstract.

Brown, G.W. and R.L. Beschta. 1985. The art of managing water. J. For. 883(10):604-615.

Water resources are in the public eye now more than ever, and with the impending Clear Water Act amendments, water quality monitoring will be required by forest managers.

Some effects of forest operations on water quality and some preventive actions are discussed.

Forest managers should invest in water research for forestry, especially studies relating to intensive forest operations or else the nation's forest and water resources could end up being managed from the courtrooms.

Brusnyk, L.M. and F.F. Gilbert. 1983. Use of shoreline timber reserves by moose. J. Wildl. Mange. 47:673-685.

The importance of shoreline timber reserves to moose (Alces alces) was studied in the Chapleau Crown Game Preserve, Ontario from fall 1978 to winter 1980. Three types (shoreline reserves, natural, and cut areas) around selected lakes were studied for seasonal use by moose using pellet-plot data supplemented by track counts and winter aerial surveys. Reserve areas had greater ($P<0.01$) pellet-group densities than the natural and cut types during both winter periods. Results of aerial surveys corroborated pellet-group findings in summer periods. Difference ($P>0.05$) in track-plot crossing were observed among study lakes. Moose preference for shoreline reserves during winter appeared related to edges. Reserve types offered a greater amount of coniferous cover adjacent to an abundant source of browse than did natural and cut areas. Summer use by moose appear to be governed by availability of suitable aquatic feeding areas and terrestrial browse of adjacent cutovers.

Authors' abstract.

Buckland L. and D. O'Brien. 1988. A study of areas of Concern following harvest. COFRDA report Project Authorization No.32005.46p.

Areas of Concern (AOC's) are used in Ontario in an effort to protect other resource values during timber management operations. Despite their widespread use, however, few studies have been under-taken to determine just how effective AOC's are. The primary purpose of this study was to evaluate specific AOC prescriptions in terms of their ability to protect various fish, wildlife, and tourism values. The impact of AOC's on various resource users was also examined.

Twenty-one AOC's in the Upper Spanish Forest Management Agreement Area southeast of Chapleau, Ontario were evaluated in the summer of 1986. Three reserve widths (30, 60, and 120 metres), three reserve types ("not cut", block cut, and sawtooth cut), and four protection objectives (warm

water fisheries habitat, moose aquatic feeding sites, wildlife cover/travel corridors, and remote tourism) were included.

Evaluation results indicated that the AOC prescriptions were effective in protecting these resource values. Individual site characteristics were more important in determining resource protection than reserve width alone. Some of the major findings of the study are summarized here. No importance should be attached to the order in which they are listed.

Authors' abstract.

Budd, W.M., P.L. Cohen, P.R. Saunders and F.R. Steiner. 1987. Determination of stream corridor widths. In: Stream Corridor Management in the Pacific Northwest . Envir, Manage, 11:587-597.

King County, Washington is a part of the rapidly growing Pacific Northwest region. This growth has placed pressure on stream corridors. Past studies about regional stream corridors provide a rich source of information for environmental planners and managers. This article draws on existing literature and case studies to provide guidelines for determining optimal stream corridor widths in a watershed located in King County, Washington.

Authors' abstract.

Burton, T.M. and G.E. Likens. 1973. The effect of strip cutting on stream temperatures in the Hubbard Brook Experimental Forest, New Hampshire. Bio. Science 23:433-435.

As a part of the Hubbard Brook Ecosystem study, a study to assess the impact of strip cutting on stream temperatures was initiated in 1970. A small watershed of Hubbard Brook Experimental Forest was divided into horizontal strips each 25 metres wide. Every second strip was logged in October 1971. In the lower part of the watershed a 10 metre strip of trees was left in each of the logged strips.

Rapid heating of 4-5° C of the stream in the cut strips and subsequent cooling (in a two hour period) in the uncut strips was observed on a hot July day. The 10 metre strips were very effective in buffering stream temperature fluctuations.

The increased stream water temperature in cut strips is a result of solar radiation.

The effects of the temperature increase by canopy removal were the elimination of larval populations of two-lined salamanders in the steam adjacent to the cut strips and the loss of leaf litter in the same areas. Blooms of algae were present also but were attributed more to increased light rather than temperature.

Temperature fluctuations can be controlled by the presence of buffer strips which shade the stream.

Carothers, S.W., R.R. Johnson and S.W. Aitchison. 1974. Population structure and social organization of south western riparian birds. American Zoologist 14:97-100.

Breeding bird populations were studied on seven riparian woodland study plots in north-central Arizona. The densities of breeding birds varied from 193 to 847 pairs per 40 hectares. These differences were, in part, related to the vegetation structure of the habitat. Bird species diversity (BSD) was not correlated with forage height diversity (FHD) in riparian habitats consisting of one major vegetational component (the cottonwood tree Populous fremontii) where these habitats are bordered by agricultural fields. These areas supported the largest breeding bird populations (847,612,512, and 425 pairs per 40 hectares) while areas consisting of a mixed deciduous tree and shrub component (Populous, Plantanus, Salix, Acer, Fraxinus, Prosopis, etc.) had smaller populations of breeding birds (322,312,and 193 pairs per 40 hectares). On the mixed deciduous woodland areas the correlation between BSD and FHD was similar to what others have found in Eastern deciduous forests.

The average weights of individual birds were significantly greater on the homogeneous cottonwood areas (mean = 46.4g) than on the mixed deciduous areas (mean = 22.9g).

Data gathered indicate that two systems of social organization are being maintained. In areas of relatively low population density (mixed deciduous) 57% of the pairs maintained "class A" territories. On areas of relatively high population density (homogeneous cottonwood) only 22% of the pairs exhibited this form of spacing; here, most birds forage freely outside of the riparian habitat.

We suggest that the differences in population density and average weight of birds found in the two habitat types are a result of the following:(1) relative productivity of areas adjacent to the riparian habitat, and (11) degree of intra-and interspecific competition effected by avian populations found breeding in areas adjacent to the riparian habitat.

Authors' abstract.

Chapman, W. 1962. Effects of logging upon fish resources of the west coast. J. For. 60:533-537.

Timber harvest of the west coast affects fish resources in a number of ways. The effects of logging on stream flow, water temperature, water quality, stream energy sources and fish movement are discussed. There is a need for further research and academic analysis. Particular effort should be made to determine the exact sources of any damaging effects so that protective steps can be planned in future harvest operations.

Corbett, E.S., J.A. Lynch and W.E. Sopper. 1978. Timber harvesting practices and water quality in the eastern United States. J. For. 76:484-488.

Data from forested experimental watersheds in the eastern United States indicate that leaching of nutrients after timber harvesting, especially clearcutting, tends to increase from south to north, while increases in streamwater temperature and sediment loadings tend to decrease. Concentrations of nutrients in streamwater are highest where revegetation of cutover areas is delayed. Also, increased streamwater temperature (in addition to increased light) caused by exposing stream channels may influence water quality by affecting a wide range of physical chemical and biological processes. Soil erosion losses from harvesting operations can be kept to acceptable levels by following available land-management guidelines, and with supervision by qualified foresters. Buffer strips, in which only light selection cutting is allowed, will help minimize sedimentation as well as nutrient leaching and stream temperature increases.

Authors' abstract.

Corbett, E.S. and J.A. Lynch. 1985. Management of stream side zones on municipal watersheds. In: Riparian Ecosystems and Their Management: Reconciling Conflicting Uses, Tuscon, Ariz. p.187-190.

Riparian zones play a major role in water quality management. Water supply considerations and maintenance of stream side zones from the municipal watershed manager's viewpoint are detailed. Management impacts affecting water quality and quantity on forested municipal watersheds are discussed in relation to the structure of the riparian zone.

Authors' abstract.

Cross, S.P. 1985. Responses of small mammals to forest riparian perturbations. In: Riparian Ecosystems and Their Management: Reconciling Conflicts Uses, Tuscon, Arizona. p. 269-275.

Trapping studies at several mixed conifer forest sites in southwestern Oregon demonstrate a differentially high use of riparian habitat by small mammals. Harsh perturbations of this habitat radically affect the presence and abundance of many species.
Riparian leave-strips were found to support small-mammal communities comparable to undisturbed sites.

Author's abstract.

Davis, G. A. 1977. Management alternatives for the riparian habitat in the southwest. In: Importance, Preservation and Management of Riparian Habitat: A symposium. p 59-67.

Exploitation, by man, has significantly altered the riparian habitat in the Southwest. For decades, the primary or dominant use of riparian habitat has been water management; other values were not considered. Management alternatives and objectives are evaluated for environmental consequences.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies design of natural resources. Biological conservation 7:129-146.

A system of natural reserves, each surrounded by altered habitat,resembles a system of islands from the point of view of species restricted to natural habitats. Recent advances in island biogeography may provide a detailed basis for understanding what to expect of such a system of reserves. The main conclusions are as follows:

The number of species that a reserve can hold at equilibrium is a function of its area and its isolation. Larger reserves, and reserves located close to other reserves, can hold more species.

If most of the area of a habitat is destroyed and a fraction of the area is saved as a reserve, the reserve will initially contain more species that it can hold at equilibrium. The excess will gradually go extinct. The smaller the reserve the higher will be the extinction rates. Estimates of these extinction rates for bird and mammal species have recently become available in a few cases.

Different species require different minimum areas to have a reasonable chance of survival.
Some geometric design principles are suggested in order to optimise the function of reserves in saving species.

Authors' abstract.

Dykstra, D.P. and H.A. Froehlich. 1976. Costs of stream protection during timber harvest. J. For. 74:684-687.

Costs of three stream-protection alternatives were analyzed: conventional felling with channel cleanup, cable-assisted directional felling, and use of buffer strips. In a study of 10 deeply incised, headwater stream channels in western Oregon, none of the three alternatives was clearly preferable on a majority of the study areas. The least-cost alternative on four of the areas was a 55-foot wide buffer strip. On three of the remaining areas, conventional felling was cheapest and on the other three, cable-assisted directional felling.

Authors' abstract.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.C. Cedarholm. 1987. Fine sediment and salmonid production: a paradox. In: Streamside Management: Forestry and Fishery Interactions, Inst. of For Res. U. of Wash. p 98-142.

The term "sediment", as commonly used by fishery biologists, means fine sediment and excludes up to 90% of sedimentary material in streams. In mountainous terrain, hill-slope erosion (primarily mass soil movements) provides periodic inputs of sediment into stream systems, often during periods of high flow when two major sediment transport mechanisms are active: (1) suspended sediment transport and (2) bedload transport. Suspended sediment consists primarily of silt and clay-size particles that may be rapidly transported downstream and locally deposited on floodplains and over-bank storage locations or that may infiltrate into gravel intersiteces of the bed. Bedload transport, consisting primarily of coarse sands or larger particles, is complex and sporadic, and has major implications regarding channel morphology and the quality of spawning gravels. It is greatly affected by large roughness elements (logs, boulder, bedrock outcrops, etc.) Hence the impacts of sediment on fish habitat are influence by both sediment availability and the subsequent routing of these materials through the channel system.

The effects of fine sediment on aquatic life have been studied intensively for more than three decades, both in situ and in the laboratory. Laboratory studies have demonstrated potential negative effects of fine sediment on macroinvertebrates, on survival and emergence of salmonid embryos and alevins, and on growth of salmonid fry. But there are significant difficulties in extrapolating these findings to the field. Nearly all laboratory survival studies have used simplified unnatural gravel mixtures to test incubation and emergence of salmonid fry. Also, mitigating factors in streams, such as structural roughness elements and spawning behaviour of female salmonids, complicate direct field application of laboratory studies.The relatively few studies dealing with the effects of sediment from forest management in natural environments have been less conclusive. Some negative effects observed in the laboratory also occur from acute of chronic sedimentation in the field. The problem with interpreting the results of field studies is that

increased fine sediment from forest management is almost always accompanied by other environmental effects. Also, field studies have shown both increases and decreases, in salmonid populations associated with forest management. The studies have generally failed to isolate the effects of fine sediment from other habitat changes.

A more holistic view of the role of sediment in stream ecosystems in needed. Undisturbed streams in the forest have stored abundant sediments in their channels and maintained an equilibrium between sediment input and sediment routing. An abundance of large organic debris and other roughness elements played an important role in the storage and routing of sediments. Forest management has broadly changed sediment storage and equilibrium in streams throughout much of the western United States. The general result has been a concurrent loss of roughness elements and accelerated routing of sediment through fluvial systems. There is evidence that stable channels containing stored sediment and large organic debris are more productive at every trophic level than either degraded channels mainly devoid of sediment or channels that are aggregated and unstable. Thus there seems to be a broad middle ground between too much and too little sediment in salmonid habitats.

Forest practice rules designed to minimize introduction of fine sediment in streams are justified, but in themselves do not ensure protection of salmonid habitats. These rules might result in improved water quality and a reduction in fine sediment in gravels, but they do not ensure protection of the physical structure of salmonid habitats. In fact, large losses of productive habitat have occurred while these rules were in force. The long-term emphasis of forest practice rules on control of water quality and fine sediment must be expanded to a more holistic view of salmonid habitat. Protection of streamside vegetation and physical structure of rearing habitat for juvenile salmonids must be given equal emphasis.

Authors' abstract.

Golladay, S.W. and J.R. Webster. 1988. Effects of Clear-cut logging on wood breakdown in appalachian mountain streams. The American Midland Naturalist 119:143-155.

Red oak (Quercus rubra) sticks, approximately 10-cm long and in three size classes (large, 3-cm diam, 22-55 g; medium, 1-2cm, 12-22 g; small, <1-cm, 3-12g) were placed at five sites in two second-order streams at Coweeta Hydrologic Laboratory. One stream, Big Hurricane Branch, drains a watershed logged in 1976 (WS 7); the other stream, Hugh White Creek, drains an uncut reference watershed (WS 14). Ten sticks of each size class were collected from each site at 6-month to 1 year intervals from September 1981 through November 1985. Calculated breakdown rates ranges from 0.107 to 0.281 1 - 1. Breakdown rates were significantly different among size classes on both watersheds - smaller sticks lost mass faster than larger sticks. Breakdown rates of similar size sticks were significantly faster in Big Hurricane Branch, the disturbed stream, than in Hugh White Creek. Faster Rates of wood breakdown in Big Hurricane

Branch may be associated with greater stream NO3-N levels, greater stream channel instability and greater invertebrate abundance on sticks.

Authors' abstract.

Gordon, Andrew, M. and N. K. Kaushik. 1986. Riparian forest plantations for wood production and stream rehabilitation: an integrated resource management approach. Summary Report O.R.R.R.G.P. Grant No. GR-073-85 17p.

In 1985, approximately 8,600 trees of selected poplar (Populous spp.) clones were planted (in replicate) in conjunction with silver maple (Acer saccharunum) and alder (Alnus spp.) in four stream-side locations throughout southern Ontario. Sites were selected for their degraded nature; trees were planted for a variety of ameliorative purposes. Survivorship after on growing season at most sites was good. The effect of these plantations on stream chemistry and fish habitat parameters is currently being investigated. Tree growth and yield studies are on-going.

An additional 1,500 trees were planted at one of the sites, Washington Creek, in 1986, in order to extend the light of the planted section along the stream. Pervious plantings were re-measured and plantations mechanically and chemically weeded.

Authors' abstract.

McNamee, P.J., M.L. Jones, L.A. Greig, C.H.R. Wedeles, D.R. Marmorek and L.P. Rattie. 1988. Effects monitoring for resource protection guidelines in Ontario. OMNR Internal Report 226p.

A monitoring program is proposed to evaluate the effectiveness of timber management guidelines in Ontario. The scope, strategies and hypotheses to be tested are described with a detailed discussion of interactions among timber management, wildlife populations, fisheries and tourism.

Authors' Summary.

Nicolson, J.A. 1975. Water quality and clearcutting in a boreal forest ecosystem. In Proc. Can. Hydrol. Symp.-75. pp.734-738. National Research Council of Canada, August.11-14, 1975, Winnipeg Manitoba.

Clearcutting resulted in increased water temperatures, suspended sediment, dissolved organic carbon and phosphorous loadings. Other parameters such as stream pH, conductivity and colour were also affected.

Conventional clearcutting in this part of the boreal forest appears to have only a minor influence on nutrient concentrations in stream water. Clearly one should be very cautious in using results from one forest type to make inferences about possible changes in other forest types.

Relatively speaking, high quality water flows from theses catchments and even a two - or threefold increase in ionic concentrations would not impair water quality. However, further study is needed to determine if these differences in nutrient concentrations could have a lasting effect on the total nutrient status of the ecosystem.

Edited Author's abstract.

Nicolson, J.A., N.W. Foster and I.K. Morrison. 1982. Forest harvesting effects on water quality and nutrient status in the boreal forest. p.71-89. In; Proc. Can. Hydrol. Symp.-82, National Research Council of Canada, June 14-15, 1982, Frederickton. New Brunswick.

Man, through harvesting and site preparation, can create major disruptions of nutrient and hydrologic cycles in forest ecosystems. Nutrient losses occur by direct removal in harvested materials and by accelerated leaching to surface runoff or percolation to groundwater.

Several small (35-170 ha) basins representing uncut and clearcuts of various ages, were monitored in the jack pine (Pinus Banksiana Lamb.) - black spruce (Picea Mariana (Mill.) B.S.P.) type in northwestern Ontario. They were selected on the premise that major disruptions should be detectable by studying a cross-section of basins in each category.

Weekly sampling occurred during the biologically active portion of the year (April-October). Concentrations of elements increased following disturbance but returned to precut levels by the second year. However, the greater volume of water flushing through the ecosystem, because of reduced evapotranspiration, resulted in additional nutrient losses from the site for several years.

By means of a considerable body of biomass and soil element data from the jack pine type throughout Ontario it was possible to establish the significance of losses by crop removal based on depletion of "available" nutrient reserves. Losses from the tree-plus-soil nutrient pool through direct removal by conventional shortwood harvesting may reach 35% of N, 20% for P, and lesser though still substantial portions for Ca and Mg. On a larger scale the significance of water quality changes due to forest management activities is discussed in relation to the Great Lakes Basin.

Authors' abstract.

Ontario. 1987. Timber Management guidelines for the protection of tourism values. Ont. Min. Natur. Resour. 96p.

Ontario. 1988a. Timber management guidelines for the protection of fish habitat. Ont. Min. Natur. Resour. 14p.

Ontario. 1988b. Timber management guidelines for the provision of moose habitat. Ont. Min. Natur. Resour. 33p.

Platts, W. S., C. Armour, G.D. Booth, M. Bryant, P. Cuplin, S. Jensen, G. W. Lienkaemper, G.W. Minshall, S. B. Monsen, R. L. Nelson, J. R. Sedell, and J. S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. General technical report INT-122. USDA For. Ser. 177p.

This report develops a standard way of measuring and evaluating riparian conditions. These methods will be helpful to those persons documenting, monitoring, predicting or evaluating riparian, stream, or range condition and how this relates to their biotic resources, especially those conditions needed to relate to impacts form land uses.

Authors' abstract.

Stephenson, T. 1988. An initial assessment of the factors affecting buffer strip survival in Northern Ontario. Thesis: Lakehead School of Forestry, 43p.

Systematic strip samples on 11 streamside buffer zones in the Thunder Bay District revealed that stability from windthrow (volume remaining following harvest in percent -VOLREM%) was significantly related to one site feature, soil stability (SOIL), according to the following equation: $VOLREM\% = 113.3 - 16.9\ SOIL$ $R^2 = 0.76$

Relationships between buffer strip stability and elevation, sticking, moisture class, width, age, tree age, species composition, volume of timber and distance from the buffer strip to uncut timber in the direction of the damaging winds proved not to be significant.

A literature review on the factors affecting wind stability recommended that windthrow could be reduced by maintaining smooth cut boundaries, by locating cut boundaries in areas of windfirm trees where possible, and by promptly regenerating cut areas so cut boundaries do not have prolonged exposure to damaging stormwinds.

Author's abstract.

Thomas, J.W., C. Maser and J.E. Rodiek. 1979. Wildlife habitats in managed rangelands - the Great Basin of southeastern Oregon Riparian Zones. USDA For. Serv. Gen. Tech. Rep. PNW-80.18p

Riparian zones are the most critical wildlife habitats in managed rangelands. More wildlife species depend entirely on or spend disproportionately more time in this habitat than any other. The zone is also disproportionately important for grazing, recreation, timber production, fisheries production, road location and water quality and quantity. The importance to wildlife is examined and guidance given for management.

Authors' abstract.

Timmermann, H.R. and J.G. McNicol. 1988. Moose habitat needs. The Forestry Chronicle, June 1988:238-245.

A review of the literature describing moose habitat needs is presented. The growing season is a period of positive energy balance when moose feed extensively on a variety of deciduous leaves, aquatic macrophytes and herbaceous vegetation which satisfy nutritional requirements for weight gain and development. In winter, a period of negative energy balance, food intake and metabolism are reduced to conserve energy and minimize weight loss. In addition, good moose winter habitat includes shelter from extreme temperatures, deep snow and access to secure areas to help avoid predators especially during spring calving. Optimum habitats contain an interspersion of food and cover within traditionally used seasonal home ranges.

Authors' abstract.

Van Groenwoud, H. 1977. Interim recommendation for the use of buffer strips for the protection of small streams in the maritimes. Can. For. Serv., Maritimes For. Res. Cent. Fredericton, New Brunswick, Int. Rep. M-X-74.18p.

Buffer strips for the protection of small headwater streams during and after clear cutting serve several purposes.
a) Protection against direct radiation and heating.
b) Protection from sediment emanating from the cut areas.
c) Protection from crossings by logging equipment.
d) Main source of food for animal life in the stream.

It is proposed that on fairly level terrain a buffer strip 15-20 m wide is sufficient to protect the stream if it extends to the origin of the stream and includes springs. On steeper terrain wider strips are required.

Author's abstract.

Wesche, J.A., C.M. Goertler and C.B. Frye. 1987. Contribution of riparian vegetation to trout cover in small streams. North American Journal of Fisheries Management 7:151-153.

Cover is an important trout habitat component from the geomorphologic characteristics of a stream channel, the stream-bank interface with the riparian community, and the stream flow. By means of regression analysis, this study quantitatively describes the relative importance of three cover parameters (overhead bank cover, rubble-boulder-aquatic vegetation areas, and deepwater areas) and two cover models as indicators of trout standing stock in eight small streams in southeast Wyoming. Results indicated that overhead bank cover, provided primarily by riparian vegetation, is the cover parameter that explains the greatest amount of variation in trout population size.

Authors' abstract.